FLUKE®

291, 292, 294

100 MS/s Arbitrary Waveform Generators

Getting Started Manual

PN 2423319
March 2006

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Safety

This generator is a Safety Class I instrument according to IEC classification and has been designed to meet the requirements of EN61010-1:2001 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1, CSA 22.2 No. 61010-1-04 and UL 61010A-1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5 °C to 40 °C, 20 % to 80 % RH (non-condensing). It may occasionally be subjected to temperatures between +5 °C and -10 °C without degradation of its safety. Do not operate the instrument while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

⚠⚠ Warning

To avoid the possibility of electric shock:

- **This instrument must be earthed.**
- **Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.**
- **When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts.**

- **Disconnect the instrument from all voltage sources before opening it for any adjustment, replacement, maintenance or repair.**
- **Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.**
- **Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.**

⚠ Caution

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Note

This instrument uses a Lithium button cell for non-volatile memory battery back-up. Typical battery life is 5 years. In the event of replacement becoming necessary, replace only with a cell of the correct type, a 3 V Li/$Mn0_2$ 20 mm button cell type 2032. Do not mix with solid waste stream. Do not cut open, incinerate, expose to temperatures above 60 °C or attempt to recharge. Used batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke Service Center for recycling information.

⚠ Caution

Do not wet the instrument when cleaning it and in particular use only a soft dry cloth to clean the LCD window.

The following symbols are used on the instrument and in this manual:

Caution - refer to the accompanying documentation, incorrect operation may damage the instrument.

Mains supply OFF.

Mains supply ON.

Alternating current.

Warning - hazardous voltages may be present.

Conforms to European Union directives:
EN61010-1-2001, EN61326

Verified by MET to be in conformance with relevant US and Canadian Standards: CSA 22.2 No. 61010-1-04, UL 61010A-1

Do not mix with solid waste stream. Dispose using a qualified recycler or hazardous material handler.

Protective Earth (Ground)

EMC Compliance

These instruments meet the requirements of the EMC Directive 89/336/EEC.

Compliance was demonstrated by meeting the test limits of the following standards:

Emissions

EN61326 (1998) EMC product standard for Electrical Equipment for Measurement, Control and Laboratory Use. Test limits used were:

a)	Radiated:	Class A
b)	Conducted:	Class B
c)	Harmonics: EN61000-3-2 (2000) Class A	The instruments are Class A by product category.

Immunity

EN61326 (1998) EMC product standard for Electrical Equipment for Measurement, Control and Laboratory Use. Test methods, limits and performance achieved were:

a)	EN61000-4-2 (1995): Electrostatic Discharge: 4 kV air, 4 kV contact	Performance A.
b)	EN61000-4-3 (1997): Electromagnetic Field: 3 V/m, 80 % AM at 1 kHz	Performance A.
c)	EN61000-4-11 (1994): Voltage Interrupt: 1 cycle, 100 %	Performance A.
d)	EN61000-4-4 (1995): Fast Transient: 1 kV peak (ac line), 0.5 kV peak (signal lines and RS232/GPIB ports)	Performance A.

e) EN61000-4-5 (1995): Surge: 0.5 kV (line to line), 1 kV (line to ground) Performance A.

f) EN61000-4-6 (1996): Conducted RF: 3 V, 80 % AM at 1kHz
(AC line only; signal connections <3 m not tested) Performance A.

According to EN61326 the definitions of performance criteria are:

Performance criterion A: 'During test normal performance within the specification limits.'

Performance criterion B: 'During test, temporary degradation, or loss of function or performance which is self-recovering'.

Performance criterion C: 'During test, temporary degradation, or loss of function or performance which requires operator intervention or system reset occurs.'

⚠ Cautions

To ensure continued compliance with the EMC directive the following precautions should be observed:

a) connect the generator to other equipment using only high quality, double-screened cables.

b) after opening the case for any reason ensure that all signal and ground connections are remade correctly before replacing the cover. Always ensure all case screws are correctly refitted and tightened.

c) In the event of part replacement becoming necessary, only use components of an identical type. Refer to the Service Manual.

Table of Contents

Getting Started

Introduction

This *Getting Started Manual* for the model 291, 292 and 294 100 MS/s Arbitrary Waveform Generators is designed to provide an initial understanding of the way the instruments are operated. The manual is set out in the form of a tutorial, guiding you through a series of basic front panel operations in order to familiarize you with the controls and the modes of operation.

The *Users Manual* contains detailed specifications and descriptions of all the functions and operations accessible both from the front panel and by means of the remote interfaces.

Before you Start

Mains Supply Voltage

Check that the instrument operating voltage marked on the rear panel is correct for the local supply. If it is necessary to change the operating voltage, follow the procedure described in appendix A of the *Users Manual*.

Externally Applied Voltages

⚠ Caution

To avoid risk of damage to the instrument:

Do not apply external voltages to the SYNC OUT or MAIN OUT sockets.

Do not apply external voltages exceeding ±10 V to the TRIG IN, MODULATION IN, SUM IN or HOLD IN sockets.

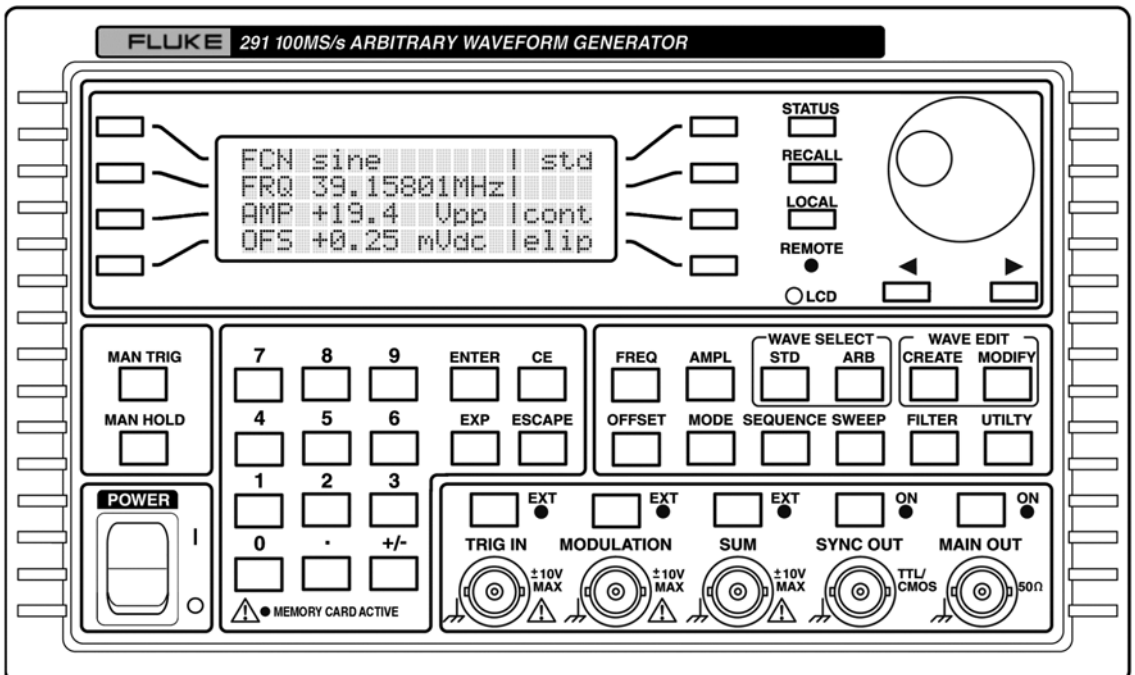
Do not apply external voltages exceeding +5 V or -1 V to the REF CLOCK IN/OUT or ARB CLOCK IN/OUT rear panel sockets.

Controls and Connections

This section is designed to familiarize you with the 100 MS/s Arbitrary Waveform Generator's basic controls and connectors. There are three versions of the instrument, models 291, 292 and 294 being single-, 2- and 4-channel versions respectively.

The *Users Manual* covers all three instruments. For this *Getting Started Manual* we refer to the model 291 single-channel instrument, except where multi-channel operations are considered.

Model 291 Front Panel

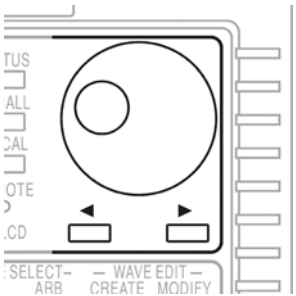


shz0001f.gif

Figure 1. Single-Channel 100 MS/s Arbitrary Waveform Generator Model 291

Principal Controls And Connectors

The **rotary control** and the two **cursor keys** below it are used to change parameter values in the LCD display, such as frequency, amplitude or dc offset.



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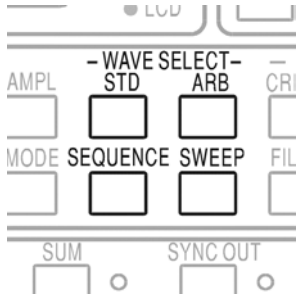
Where the symbol ▲▼ appears next to a menu choice, the rotary control lets you select the appropriate item from a list.

Where a numeric parameter value is editable a flashing cursor below one of the digits indicates the step by which the rotary control will increment or decrement the value. The flashing cursor can be moved left or right using the keys below the rotary control.

The **WAVE SELECT** keys call screens from which all standard or already defined arbitrary waveforms can be selected.



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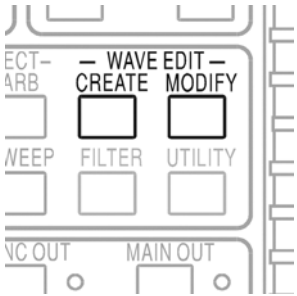
Pressing the **STD** key gives the `STANDARD WAVEFORMS` screen on the LCD display, which lists the waveforms available (sine, square, triangle, etc.).

Pressing the **ARB** key causes the LCD display to list the arbitrary waveforms held in memory. The **SEQUENCE** key is used when you want to create sequences of arbitrary waveforms. (For information on the programming and use of arbitrary waveforms, refer to the *Users Manual)*.

Pressing the **SWEEP** key brings up a menu of sweep parameters: frequency range, sweep time, direction, etc.

WAVE EDIT keys call screens from which arbitrary waveforms can be created, modified, combined, etc.

The **CREATE** and **MODIFY** keys allow you to create a new waveform or modify an existing waveform using the front panel controls.



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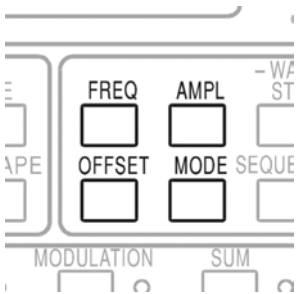
FREQuency, **AMPL**itude, **OFFSET** and **MODE** keys display screens which permit their respective parameters to be edited either from the numeric keypad or by using the rotary control and the cursor keys.



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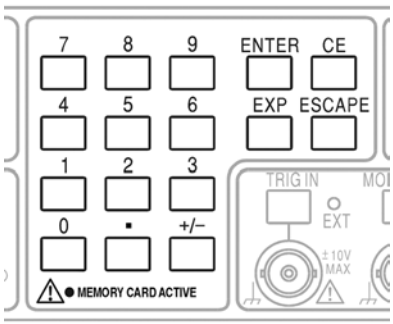
Frequency and amplitude are self-explanatory; **OFFSET** refers to the instrument's ability to apply a dc offset voltage to the waveform output, and the **MODE** key lets you determine whether the output is continuous, triggered, gated or swept and also provides for tone generation.

Numeric keys permit direct entry of a value for the parameter currently selected. Values are accepted in three formats: integer (**20**), floating point (**20·0**) and exponential (**2 EXP 1**).



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For example, to set a new frequency of 50 kHz, you can press **FREQ** followed by **50000 ENTER** or by **5 EXP 4 ENTER**.

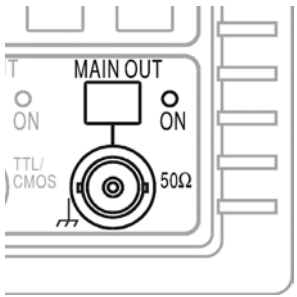
ENTER confirms the numeric entry and changes the generator's setting to the new value.

CE (Clear Entry) undoes a numeric entry digit by digit. **ESCAPE** returns a setting being edited to its previous value.

The **MEMORY CARD ACTIVE** lamp under the numeric keys indicates that the Compact Flash card reader is operating, and that the card should not be removed or its contents may become corrupted.

On the model 291 single channel instrument the card reader is located on the instrument's rear panel; on the multi-channel instruments it is on the front panel.

Each channel has a key which directly switches the **MAIN OUT** of that channel on and off. The LED **ON** lamp indicates when the output is on.



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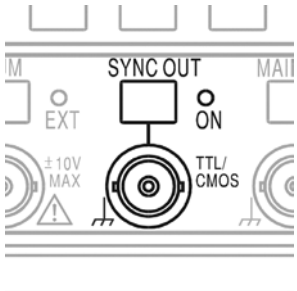
The **MAIN OUT** socket is the 50 Ω output from the channel's main generator. It provides up to 20 V p-p into an open circuit or 10 V p-p into a matched 50 Ω load. It can tolerate a short circuit for 60 seconds.

The **SYNC OUT** key calls an LCD display in which you can set the parameters of the sync output, including whether the port is on or off. The LED is lit when the output is on.



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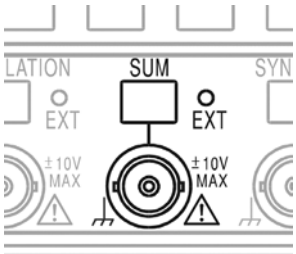
The **SYNC OUT** socket provides a TTL/CMOS level output for a number of synchronization signals which you can select using the front panel controls. It can be used to trigger an oscilloscope or provide a Z-axis bright-up marker, or to deliver various forms of gating and triggering for external instruments and systems.

This drawing and the one above show the **SYNC OUT** and **MAIN OUT** key, the LED and the socket for the single-channel instrument. On the multi-channel versions the **MAIN OUT** sockets, LEDs and keys are grouped with their corresponding **SYNC OUT** sockets, LEDs and keys.

The **SUM** socket accepts an external signal in the range ±10 V which can be added to the signal generated internally. Multi-channel instruments can also add signals internally from one channel to the next.



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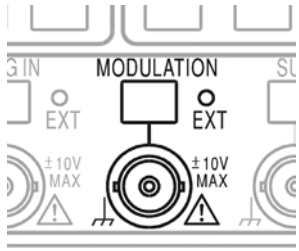
Pressing the **SUM** key brings up an LCD screen in which you can set the source, attenuation and on/off state. The LED indicates whether the external signal is enabled or not.

The **MODULATION** socket accepts an external signal in the range ±10 V which you can use to modulate the internally-generated signal. Multi-channel instruments can also use signals generated in one channel to modulate the next channel.



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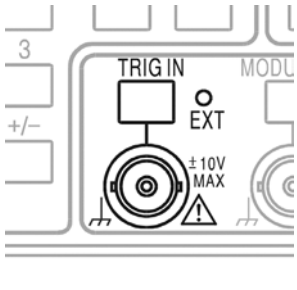
Pressing the **MODULATION** key brings up an LCD screen in which you can set the source, modulation type and on/off state. The LED indicates whether the external modulation signal is enabled or not.

The **TRIG IN** socket accepts an external trigger signal in the range ±10 V (with a threshold at 1.5 V) which you can use for burst mode or for gating.



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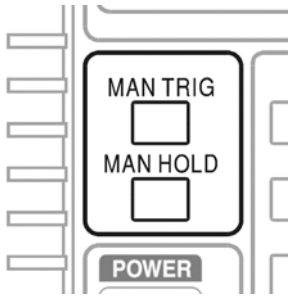
Pressing the **TRIG IN** key brings up an LCD screen in which you can set the source and slope of the trigger signal.

The LED indicates whether the external trigger signal is enabled or not.

The **MAN TRIG** key is used for manual triggering (when **TRIG IN** is appropriately set) and for synchronizing two or more linked generators.



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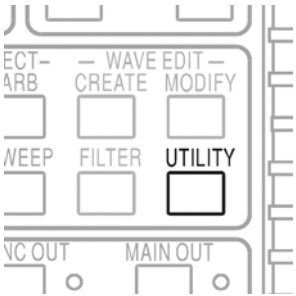
The **MAN HOLD** key lets you manually pause arbitrary waveform output and sweep; the output is held at the level it was at when **MAN HOLD** was pressed.

The **UTILITY** key gives access to menus for a variety of functions such as remote control interface set-up, power-up parameters, error message settings, and storing and recalling set-ups to and from the instrument's memory card.



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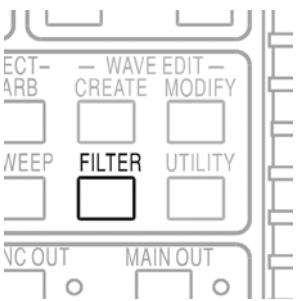
The **FILTER** key brings up an LCD display in which you can override the default output filter settings.



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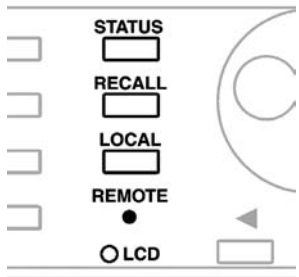
The **STATUS** key always returns the display to the default start-up screen (shown in figure 1 above) which gives an overview of the generator's status. Pressing **STATUS** again returns the display to the previous screen.



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The **RECALL** key is used to recall items from the instrument's internal non-volatile memory. Multi-channel instruments also have a **STORE** key; on the single-channel instrument this function is provided by soft keys. The **LOCAL** key is used to bring the instrument back to local (i.e. front panel) control when it has been used in remote mode (indicated by the **REMOTE** LED).

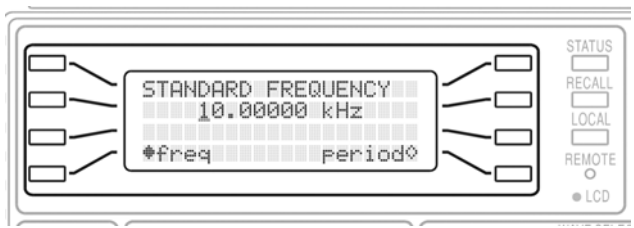
The Compact Flash Card Reader/Writer

These Arbitrary Waveform Generators use removable Compact Flash cards to store both set-up information and arbitrary waveforms.

On the model 291 the card reader/writer slot is on the rear panel; on the multi-channel instruments it is on the front panel.

The Liquid Crystal Display Panel

The 4-line x 20-character LCD panel is used to display and edit all the parameter values and to indicate and change modes.



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Four soft keys at each side of the screen let you select screen items. Selected items are indicated by a filled diamond (♦) and unselected items by a hollow diamond (◊).

Contrast adjustment

The contrast of the LCD panel can be adjusted by means of a rotary control behind the panel and accessed using a small screwdriver through the hole marked **LCD**.

Multi-Channel Instruments - Front Panel Differences

The *Users Manual* contains drawings of the model 292 and 294 front panels.

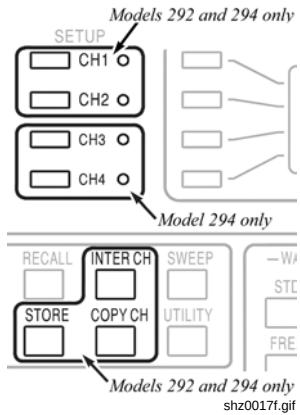
The controls of the two- and four-channel versions are the same as those of the single channel version in all respects except:

1. there are two or four pairs (respectively) of **MAIN OUT** and **SYNC OUT** sockets, and
2. the front panel is wider to accommodate the additional outputs, which also means that the layout of the keys is different, and
3. the Compact Flash card reader/writer slot is on the right side of the front panel (not the rear panel as on the single-channel version), and
4. there are certain keys which do not exist on the single-channel instrument, as follows:

The **STORE** key: on the single channel instrument the store function is accessed by means of a soft key

The **INTER CH** key: used for phase locking between channels

The **COPY CH** key: used for copying settings and waveform information between channels



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The **CH1** to **CH2** (2-channel) or **CH4** (4-channel) **SETUP** keys: used for channel selection.

When a channel select key is pressed, subsequent front panel key presses operate on the selected channel until a different channel select key is pressed.

LEDs adjacent to the channel select keys indicate which channel is currently selected.

Using the Instrument

While familiarizing yourself with the instrument you will find it useful to observe the outputs on an oscilloscope. For most purposes it is sufficient to connect the **MAIN OUT** socket to the oscilloscope's Y input and the **SYNC OUT** socket to the oscilloscope's trigger input.

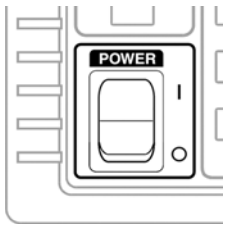
If no oscilloscope is available you can still learn a great deal about the instrument settings, since the effect of front-panel operations is visible in the LCD display in the form of text messages, parameter information, menus and status information.

The following sections are written in the form of a tutorial.

Starting up

The ac **POWER** on/off switch is located at the bottom left side of the front panel.

On multi-channel models the switch is mounted horizontally.



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Caution

Before connecting to the ac supply, check that the supply voltage setting is correct for the region. Refer to the *Users Manual* if the supply voltage is different from that shown on the rear panel.

Plug in and switch on the instrument.

At power-up the LCD panel illuminates and the instrument performs a series of self tests. In the event that an error message is displayed, please refer to the *Users Manual*.

Check the LCD display

At start-up the instrument will perform a series of internal self tests, during which the software version number is displayed. After a few seconds the display should be the status screen as shown in figure 1, the Model 291 front panel drawing above.

In the unlikely event that an internal fault is discovered there will be a message displayed in place of the status screen. You should refer to the *Users Manual* if this happens.

Check the start-up settings

It is possible that although the status screen is displayed correctly the settings indicated are different from those in the front panel drawing. This happens when the instrument has been set to resume the power-down settings on power-up, instead of the factory defaults. To change the power-up settings, do the following:

1. Press the **UTILITY** key. This brings up a menu of several settings and other functions.
2. Press the right cursor key several times until you see ◊`power on…` in the display.
3. Press the soft key to the left of this menu item.
4. In the next screen press the soft key to the left of ◊`default values`. The diamond will fill, indicating that this option is now selected, so the display will now show ♦`default values`.
5. Turn off the power, wait 10 seconds, then switch on again.

This will ensure that the instrument is in a known state for the purposes of this tutorial.

Generating Sine Waves

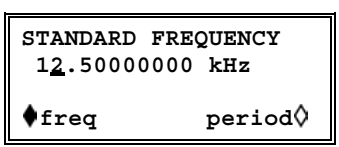
Press the **FREQ** key. The display should look similar to the drawing in the previous section.

With the frequency display shown you can experiment with the rotary control and the cursor keys below it to adjust the frequency setting. You can also experiment with entering frequencies using the numeric keypad.

Set a frequency, for example 12.5 kHz

You can do this by either of the methods above. The easiest is probably to key **12500 ENTER** or **12.5 EXP 3 ENTER**.

The display should look like this:

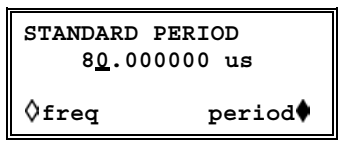


The solid diamond against the word `freq` indicates that any new keypad entry or any change made using the rotary control will apply to the frequency.

You can also view or enter information in terms of period.

Press the soft key at the bottom right, adjacent to the word `period`.

The display should look like this:

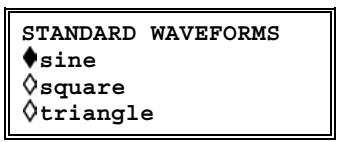


The solid diamond is now against the word `period` indicating that any new keypad entry or any change made using the rotary control will apply to the period.

The word `STANDARD` in the display heading indicates that the instrument is set up to generate one of the standard waveforms. You can choose the waveform you wish to generate.

Press the **STD** *key*

The display should look like this:



`sine` is the default setting. You can explore the full list of standard waveforms using the cursor keys or the rotary control.

The instrument can also generate arbitrary waveforms which are specified as a series of values from -2047 to +2047 (corresponding to a peak to peak amplitude range of 20 V) along a timebase of up to 1,048,576 points.

These are stored on the memory card and can be created and edited from either the front panel or on a PC using suitable software.

Waveforms created on a PC can be written directly to the memory card using the USB card reader/writer, or downloaded to the instrument via the RS232, GPIB or USB interfaces.

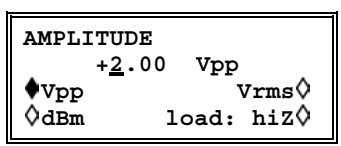
Arbitrary waveforms are discussed later in this *Getting Started Manual*.

For this part of the exercise we will concentrate on the standard waveforms. At this point we have set up a sine wave at 12.5 kHz.

The amplitude of the signal at the output socket is controlled in the same manner as the frequency or period:

Press the **AMPL** *key*

The display should look like this:



This indicates that the output amplitude is 2 V p-p into an open circuit (`hiZ`).

You can experiment with other settings; for example, selecting Vrms will change the indicated value from `2.00 Vpp` to `707 mVrms`.

The output levels above are for a high impedance load. You can experiment to see the effect of changing the load

to 600Ω or 50Ω (the latter halves the output voltage because the output impedance of the instrument is 50 Ω).

You can also display the output level in dBm (dB relative to 1 mW in the specified load).

For example, if you set the load to 600Ω and the rms amplitude to 775 mVrms, then switch the display to dBm, the display will show:

```
AMPLITUDE
      +00.0 dBm
◊Vpp              Vrms◊
♦dBm       load:600Ω◊
```

Note that the Vrms and dBm amplitude displays are not available for certain standard waveforms.

The following sections assume a sine wave unless specified otherwise.

You can also apply a dc offset to the output:

Press the **OFFSET** *key*

The display will show:

```
DC OFFSET:
 program +0.00  mVdc
 (actual +0.00  mVdc)
          load:hiZ◊
```

This display assumes that the instrument has been set up to deliver a 2 V p-p sine wave into a high impedance load.

You can change the programmed value of the dc offset.

For example, pressing **1 ENTER** on the key pad changes the display to:

```
DC OFFSET:
 program +1.00   Vdc
 (actual +1.00   Vdc)
          load:hiZ◊
```

The output stages of the instrument include a variable gain amplifier and a 0 to 50 dB attenuator in 10 dB steps. Thus if you subsequently reduce the amplitude such that the

stepped attenuator switches, the actual and programmed values of the DC offset will be different. In the event you will be warned by a text message on the display.

You can experiment, for example, by changing the amplitude from 2 V p-p to 200 mV p-p using the key sequence **AMPL 0.2 ENTER**.

The instrument will give an audible beep and the display will show:

```
****  WARNING 13  ****
 DC offset changed by
      amplitude
```

If you then press **OFFSET** again the display will show:

```
DC OFFSET:
 program +1.00   Vdc
 (actual +100.  mVdc)
           load:hiZ◊
```

This is because the amplitude change has resulted in a change of 20 dB in the stepped attenuator, and this change applies equally to the amplitude and the DC offset.

Note that the precise value of the actual offset also depends upon the attenuator's stored calibration factors and may therefore be marginally different from those shown above.

Generating a Swept Output

You can generate swept, phase-continuous sine waves and other waveforms.

Press the **SWEEP** *key*

The sweep set-up display is as follows:

```
SWEEP SETUP:     off▲▼
◊range…        type…◊
◊time…       spacing…◊
◊manual…      marker…◊
```

Each of the submenu items leads to a second screen in which you can set the parameters chosen; for example the `range…` soft key allows you to set the sweep range in terms of either start and stop frequency or of center frequency and span.

Experiment by setting up a continuous linear sweep, taking 100 ms to go from 40 kHz to 70 kHz in the upward direction, with a marker at the middle of the sweep (55 kHz).

Once all the parameters are set, you can turn the sweep on and off using the cursor keys.

Note that the sweep marker occupies the period of one of the steps of the sweep. The step chosen is the one with the frequency closest to the programmed marker frequency. If you have followed the steps above and the sweep is turned on, you should see that the actual marker frequency is 54.96 kHz, not 55.00 kHz.

Other Standard Waveforms

You saw earlier that the list of standard waveforms includes sine, square, triangle, dc, negative- and positive-going ramps, haversine, cosine, havercosine, sin(x)/x, pulse and pulse-train waveforms. In addition, the selections include arbitrary and sequence for simplicity of switching between these and standard waveforms; they do, however, have their own screens (accessed by pressing **ARB** and **SEQUENCE** respectively).

Most waveforms are generated by direct digital synthesis; square waves, pulses and pulse trains, arbitrary waveforms and sequences are generated by clock synthesis.

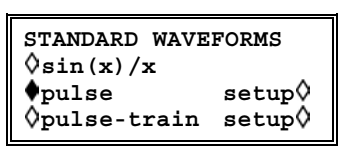
There are comparative descriptions of both methods in the *Users Manual*.

For the purposes of this *Getting Started Manual* it is not necessary to understand the internal synthesis processes but it is useful to know the effect on the possible frequency resolution. For direct digital synthesis it is 10^{-4} Hz (0.1 mHz); for clock synthesis it is 10^{-1} Hz.

Of the standard waveforms, most are self-explanatory. The limits of frequency and amplitude vary somewhat from case to case and are covered in full in the specifications section of the *Users Manual*. However, the pulse and pulse-train settings are significantly different, and will be examined next.

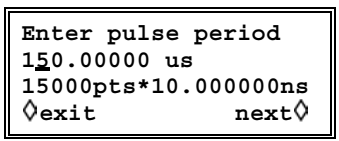
Select `pulse` *on the* `STANDARD WAVEFORMS` *screen*

The display will include a set-up option to the right of the pulse selection:



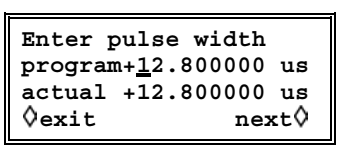
The set-up selection will lead you through a series of screens where you can define the pulse period, the pulse width and the pulse delay.

You will find it easiest to edit these parameter values using the rotary control.



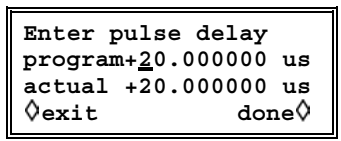
The third line of the screen indicates the way the waveform will be constructed (in this case, 15,000 points clocked out at 10 ns intervals.

The actual values for the pulse width and delay may differ slightly from the programmed values because of the way the pulse is assembled internally. An explanation for this is given in the *Users Manual*.



After the first two screens the word `next` appears at the bottom right; in the final screen it is replaced by the word `done`.

Pressing the `done` soft key concludes the pulse set-up.



You can also define pulse trains of up to 10 pulses, each of which is defined in terms of width, delay and amplitude. They all share a common baseline voltage, which you can set in the set-up sequence.

For a pulse train of n pulses there are 3 + 3n screens in the set-up. The first three are used to set the number of pulses (n), the pulse train period (i.e. the repetition period for the entire pulse train) and the baseline voltage.

The next 3n screens set the level, width and delay for each of the n pulses.

Triggered Modes

So far we have considered only continuous modes of operation. The instruments also offer gated and triggered modes.

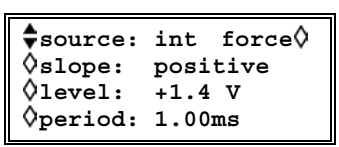
This section of the *Getting Started Manual* only covers the burst mode of operation, which is an output of defined length triggered by an edge at the **TRIG IN** socket, a signal taken from another channel, the internal trigger generator or a press of the **MAN TRIG** key.

The gated mode is level-sensitive; a signal at the **TRIG IN** socket or a signal from another channel determines whether the output is on or off.

There is a detailed account of both gated and triggered burst modes in the *Users Manual*.

Press the **TRIG IN** *key*

You should see a display like this:



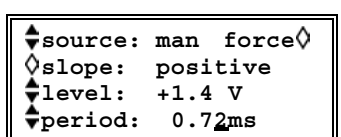
Using the cursor key you can change the `source` between the `internal` trigger generator, an `external` input or the **MAN TRIG** front-panel key. On multi-channel instruments the source may also be another channel. For the purposes of this exercise you should choose `int` as the source.

The `force` soft key is used only to initiate triggering in cases where a closed ring of generators is each waiting for a trigger signal from its neighbor; it is in effect a manual override trigger key for use when the source is not set to manual.

For this exercise, we will produce a triggered burst of 3 cycles of a 12.5 kHz sine wave with a duty cycle of 1:2 (on:off). The settings for the standard wave are the same as those discussed earlier; one cycle has a period of 80 µs. The total repetition cycle period of the trigger is 240 µs on plus 480 µs off, total 720 µs.

Set the period to 0.72 ms (**0.00072 ENTER**).

The display should now look like this:



Turn on the Triggered Mode

Do this by pressing the **MODE** key and selecting `triggered` on the screen, which should now look like this:

```
MODE:
◊gated          setup…◊
♦triggered      setup…◊
◊sweep          setup…◊
```

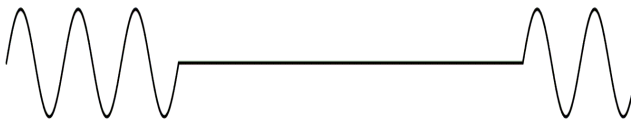
Now press the soft key for the `triggered setup…`

```
TRIGGER/GATE SETUP:
♦burst cnt: 0000003
◊phase:   +000.0°
 (actual: +000.0°)
```

You can set the number of waveform cycles to any integer value from 1 to 1,048,575; set it to 3.

You can also control the start and stop phase of the waveform between 0 and 359.9 degrees.

If you are observing the output on an oscilloscope triggered from the **SYNC OUT** socket, it should look something like this:



You can observe the effect of adjusting the phase and burst count.

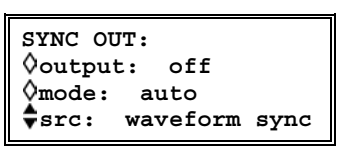
Using the Synchronization Output

The **SYNC OUT** socket provides various signals which you can set up. These include the provision of a range of trigger or bright-up marker signals for oscilloscopes, other instruments and test devices, and signals for synchronizing additional generators.

You should refer to the *Users Manual* for a full explanation of the more complex applications of the **SYNC OUT** signal; for the purposes of this *Getting Started Manual* we will restrict the discussion to the generation of trigger signals for oscilloscopes and other external devices.

Press the **SYNC** *key*

You should see a display like this:



The first soft key toggles the `output` between `on` and `off`, and the second toggles the `mode` between `auto` and `manual`.

The `src` choices are as follows:

`waveform sync:`	For most of the waveforms the output is a square wave at the main waveform frequency.
`burst done:`	Produces a pulse coincident with the last cycle of the burst.
`sequence sync:`	Produces a pulse coincident with the end of a waveform sequence, (i.e. a sequence of arbitrary waveforms). Sequence generation is covered in full in the *Users Manual*.
`trigger:`	Selects the current trigger signal (internal, external, adjacent channel or manual).
`sweep sync:`	Outputs the sweep trigger signal.
`phase lock:`	Used to lock two or more generators. Produces a positive edge at the 0º phase point.

You can observe the effect of changing the `SYNC OUT` settings on the oscilloscope' s triggering.

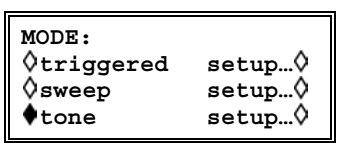
Tone Mode

In tone mode the output is stepped through a list of up to 16 frequencies under the control of the trigger signal or front panel **MAN TRIG** key.

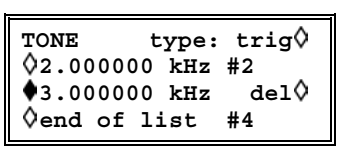
You can control the instrument's response to the trigger signal and the frequencies in the list from the set-up screen.

Press the **MODE** *key and navigate to* `tone`

The **MODE** key produces a display like this (if `tone` is not visible, navigate down the list using the cursor keys):



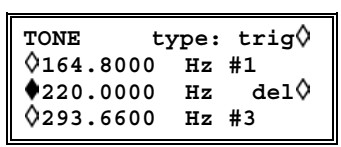
The `setup…` soft key next to the tone selection leads to the set-up screen:

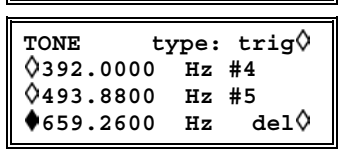


The `trig` type uses the trigger source to switch from the current tone to the next. The other two types, `gate` and `fsk` (frequency shift keying) are outside the scope of this *Getting Started Manual* but are covered in detail in the *Users Manual*.

If there are more than three tones defined in the list you can navigate up and down using the cursor keys. You can enter the frequency of each tone using the numeric keypad or the rotary control, and you always have the option to delete the currently selected tone using the `del` soft key. For the unselected tones the word `del` is replaced by the numeric position in the list.

As an exercise for this *Getting Started Manual* you could set the frequencies of six tones to tune a guitar.
The frequencies for E, A, D, G, B, E tuning (based on A=440 Hz) are shown in these two screens:





You should also press the **TRIG IN** key and check that the trigger source is `manual`.

You can now step through the six audio frequencies using the **MAN TRIG** key and listen to them on headphones attached to the **MAIN OUT** socket.

One of the important uses for the tone generation capability of a multi-channel instrument is for DTMF (dual tone multi-frequency) testing of telephony equipment and systems. This use is described further in the *Users Manual*.

Saving and Recalling Settings

The instrument's built-in card reader/writer lets you use Compact Flash cards to save both instrument set-ups and arbitrary waveforms. On the single-channel instrument the card slot is on the rear panel; on multi-channel instruments it is on the front panel.

Using the instrument's Compact Flash Card Reader/Writer

Place the memory card in the memory card slot, ensuring that the pointer on the card aligns with the pointer on the card slot. Push the card gently until it is fully engaged in the connector. You can insert the card with the power on or off.

When a card is inserted in a powered instrument the message

```
Opening memory card
```

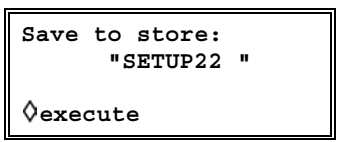
will appear on the bottom line of the screen, the **MEMORY CARD ACTIVE** lamp will light and a short beep will sound. The card is then ready for use.

Storing and Recalling Set-Ups

Set-ups are stored on the Compact Flash card in their own directory. You can store and recall complete set-ups using

the screens called by the **STORE** and **RECALL** keys. On the single-channel instrument the store function is accessed via the `UTILITY` menu.

Pressing **STORE** or the `STORE` soft key calls this screen:



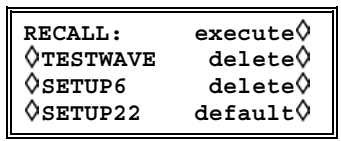
You can enter a unique name with up to eight characters for your stored set-up using the left and right cursor keys and the rotary control.

The left and right keys step the edit cursor through the eight possible character positions of the name and the rotary control is used to scroll through all valid character choices.

Once the unique name has been entered, you can save the current instrument set-up to that store name by pressing the execute soft-key.

If the name already exists you will be asked whether you want to overwrite the file.

Pressing **RECALL** calls the RECALL screen:



You can scroll through the full list of stored set-ups using the rotary control.

Removing the Memory Card

To remove the memory card, first ensure that the **MEMORY CARD ACTIVE** lamp is off, then pull the card straight out of the card slot.

⚠Caution

To avoid the risk of malfunction, card data corruption or firmware lock-up, never remove the memory card when the MEMORY CARD ACTIVE lamp is lit.

Arbitrary Waveforms

Arbitrary waveforms are stored on the Compact Flash card in their own directory as `<filename>.WFM`, where `<filename>` has up to eight characters.

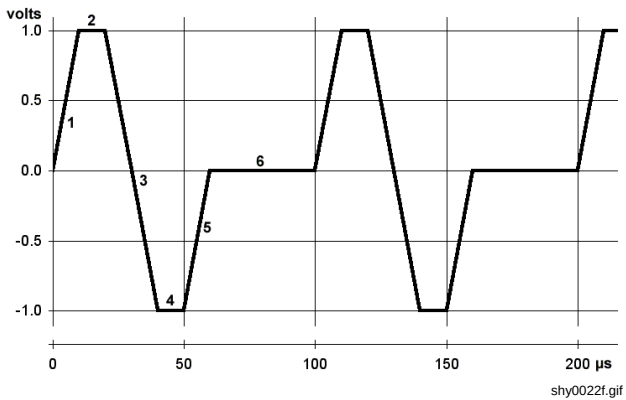
Within the file and within the instrument, waveforms are represented as a series of values from -2048 to +2047, corresponding to the peak to peak output voltage range; the number of points in the series can be anything from 8 to 1,048,576. The default number of points for a new waveform is 1024.

Waveforms can be defined using many different methods, of which the easiest is to use is a waveform synthesis program on a PC. The CD-ROM supplied with the instrument includes applications for this purpose. Waveforms can be moved between the PC and the instrument using either a remote control interface (RS232, USB or GPIB) or the Compact Flash card.

Waveforms can also be defined, edited, copied and pasted using the front-panel controls, provided a Compact Flash card is present.

Creating a New Waveform

In this exercise we will create a simple waveform as shown below:



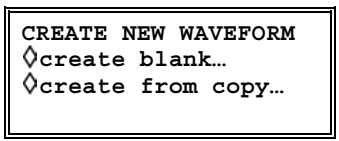
shy0022f.gif

The waveform has 6 segments numbered 1 to 6 over a period of 100 µs. The segments start and end at multiples of 10 µs.

First, make sure the Compact Flash card is in its slot.

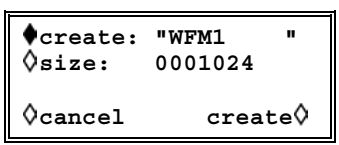
Then press the **CREATE** key.

You should see this screen:



Select `create blank…`

You should see this screen:



Change the size to 100. This will give a time resolution of 1 µs for the repetition rate of 100 µs.

Change the name to something recognizable, such as `MYWAVE`. You can do this by using the cursor keys to select each letter position in turn, then using the rotary control to choose the character. (By using only numeric digits and upper case letters you can ensure the name complies with the Windows 8.3 filename convention; this will prevent the creation of additional directory entries when the card is mounted as a PC volume.)

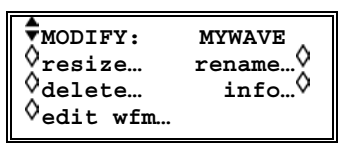
Select `create`. Your new waveform will appear in the list of saved waveforms. This waveform (MYWAVE.WFM) now exists as a file in the memory card's directory and contains a series of 100 values, all of which are currently zero.

Modifying a Waveform

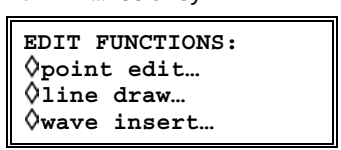
The next step is to begin modifying the data to contain the shape above. Make sure `MYWAVE` is selected.

Press the `MODIFY` soft key.

You should see this screen:



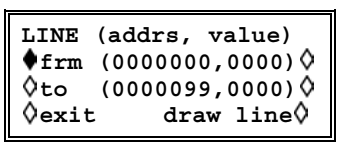
Press the `edit wfm…` soft key



This gives you the ability to edit point-by-point, to draw straight lines between pairs of points, or to insert other waveforms between pairs of points:

Press the `line draw…` soft key

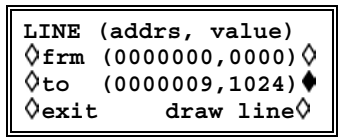
The display initially offers a line covering the entire range of points from 0 to 99:



For the first segment, the addresses are from 0 to 9 and the corresponding voltages go from zero to 1 V.

To provide some headroom, we'll decide to use a full-scale range of -2 V to +2 V, so 1 volt is represented by a value of +1024 (full-scale being +2047).

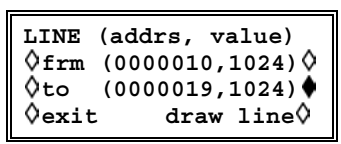
Set the screen as shown here, using the soft keys to select the `to` row and the numeric keypad to enter the value pair (9,1024).



Don't forget to press **ENTER** after each numeric entry.

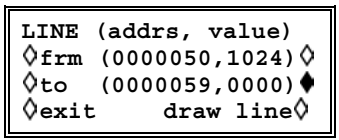
Pressing the `draw line` soft key will complete segment 1 of `MYWAVE`.

The same screen will reappear, so that the values for segment 2 can be entered. (It's best to set the `to` address before the `frm` address.)

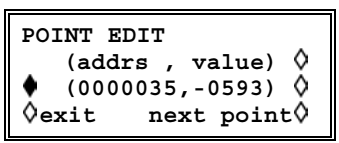


After you have done that, press the `draw line` soft key again.

Continue doing this until you have entered segment 5 (there is no need to enter segment 6 because all the values are zero). The segment 5 screen looks like this:



You can see how the interpolations have been calculated by stepping through the waveform using the `point edit…` screen:



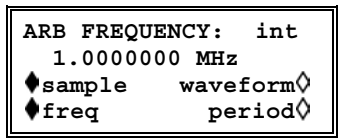
Congratulations - you have now created an arbitrary waveform.

Setting the Repetition Rate

The next step is to set up the repetition frequency.

Press the **FREQ** key.

This time, the display shows the frequency of the arbitrary waveform, initially in terms of the sample rate. Set this to 1 MHz:



The solid diamonds indicate that the display is in fact the sample frequency.

You can select `period`, which will change the display to the sample period (1.000 µs), and you can select `waveform`, which will change the display to show the waveform repetition period (100.0 µs). If you then select `freq` again you will see the waveform repetition frequency, 10 kHz.

You might wish to experiment with the `wave insert…` function to see how arbitrary waveforms can be built from sine waves and other shapes.

Other Functions

This family of 100 MS/s Arbitrary Waveform Generators offers many features which are beyond the scope of a *Getting Started Manual*.

Topics not mentioned here include the ability to be driven through GPIB, USB and RS232 interfaces, the ability to add the outputs of other channels, other generators and external devices to the output signal, the ability to modulate the output, the ability to produce complex pulse trains (where the baseline and height can be controlled independently) and the internal calibration routines. The instrument's synchronization and triggering capabilities provide the means to generate multiple waveforms and sequences of almost unlimited complexity.

These subjects are covered in detail in the *Users Manual*.